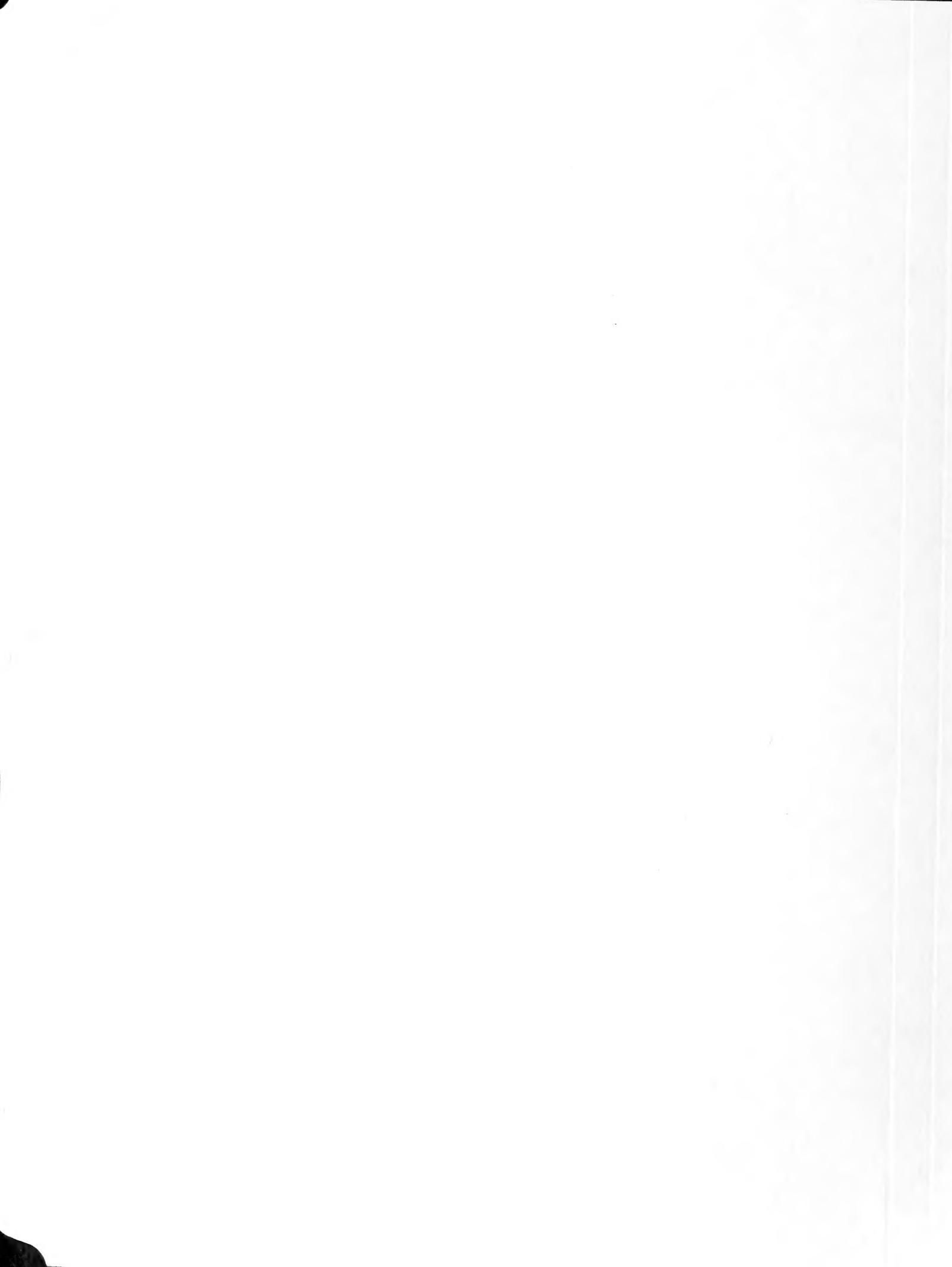


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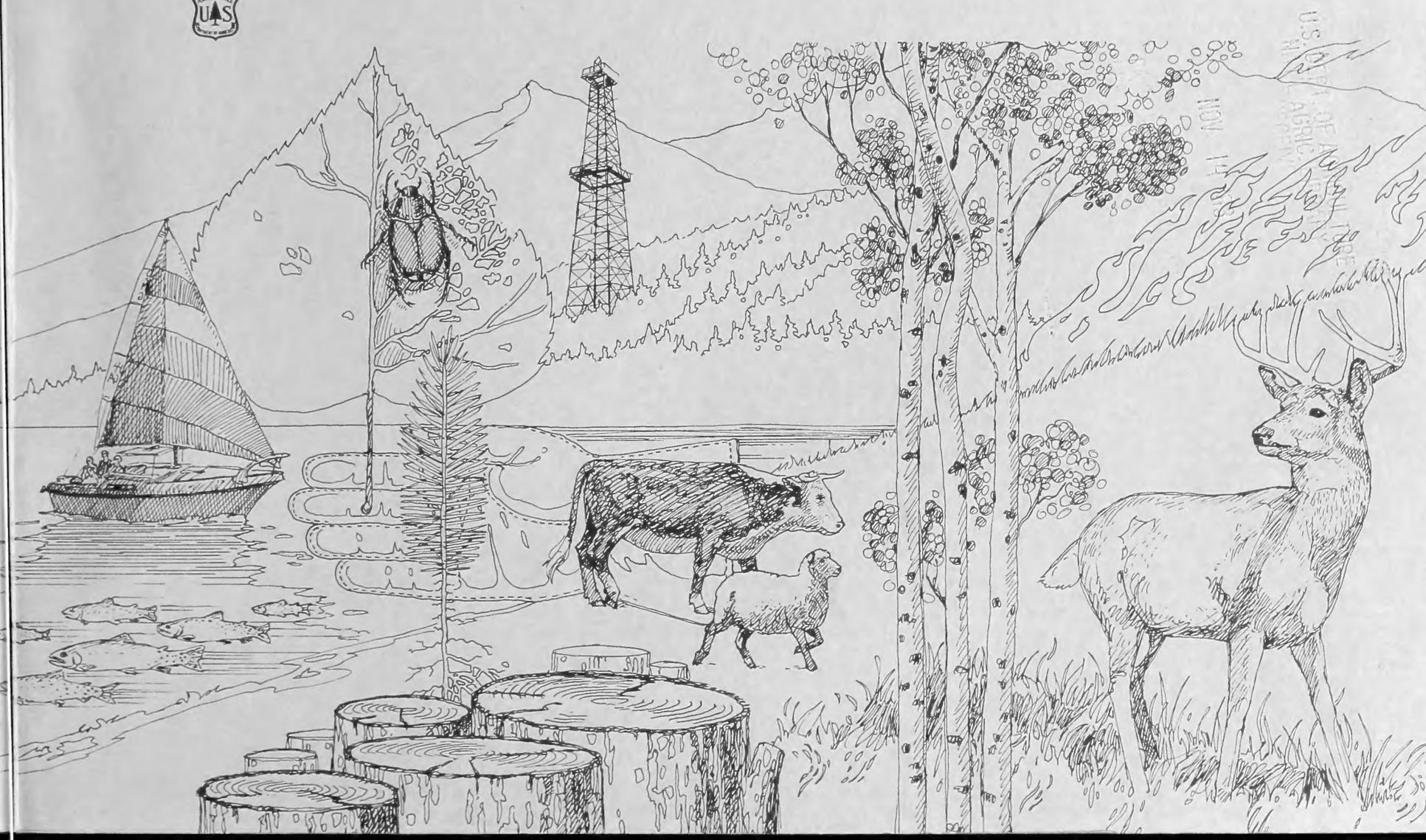
Forest
Service

General
Technical
Report
WO-30



Improving Productivity on Forests and Rangelands

1980 Research Accomplishments





IMPROVING PRODUCTIVITY ON FORESTS AND RANGELANDS

1980 Research Accomplishments

General Technical Report WO-30
June 1981

FOREWORD

One of the major responsibilities of the Forest Service is forestry research — providing the information needed to manage and protect forest and related lands, gain maximum benefit from their use, and leave the environment unspoiled.

To accomplish these goals and to help solve the forestry problems confronting the Nation, we conduct research at eight regional forest experiment stations throughout the country and at the Forest Products Laboratory in Madison, Wisc. A map on page 135 shows the location of these research facilities. We also conduct international studies in forestry, as well as cooperative research with universities and other organizations.

The Forest Service research program addresses a variety of problems associated with increasingly complex land management challenges. The scope of the research program includes studies in seven broad areas:

1. Timber Management.
2. Fire and Atmospheric Sciences.
3. Forest Insects and Diseases.
4. Renewable Resources Evaluation and Economics.
5. Forest Products Utilization and Engineering.
6. Environmental Research including Range, Wildlife, and Fish Habitat; Watershed Management; Surface Mine Land Rehabilitation; and Recreation.
7. International Forestry Programs.

This report highlights the kinds of research in progress. Some of the articles report developments in ongoing projects; others describe completed research and how the findings are being applied.

Starting on page 49 is a list of all publications issued by the Forest Service staff during fiscal year 1980. This list, categorized by subject, suggests the diversity of our research programs. The categories are not mutually exclusive, so even though you may be primarily interested in one subject, you will find related information in other categories.

For further information on accomplishments in which you are particularly interested, please contact the research headquarters mentioned in the highlights. Their addresses are on the inside back cover.



R. MAX PETERSON
Chief

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Acknowledgment

Delpha Noble, Public Information Officer at the Intermountain Forest and Range Experiment Station, was primarily responsible for collecting and preparing the material presented in this report.





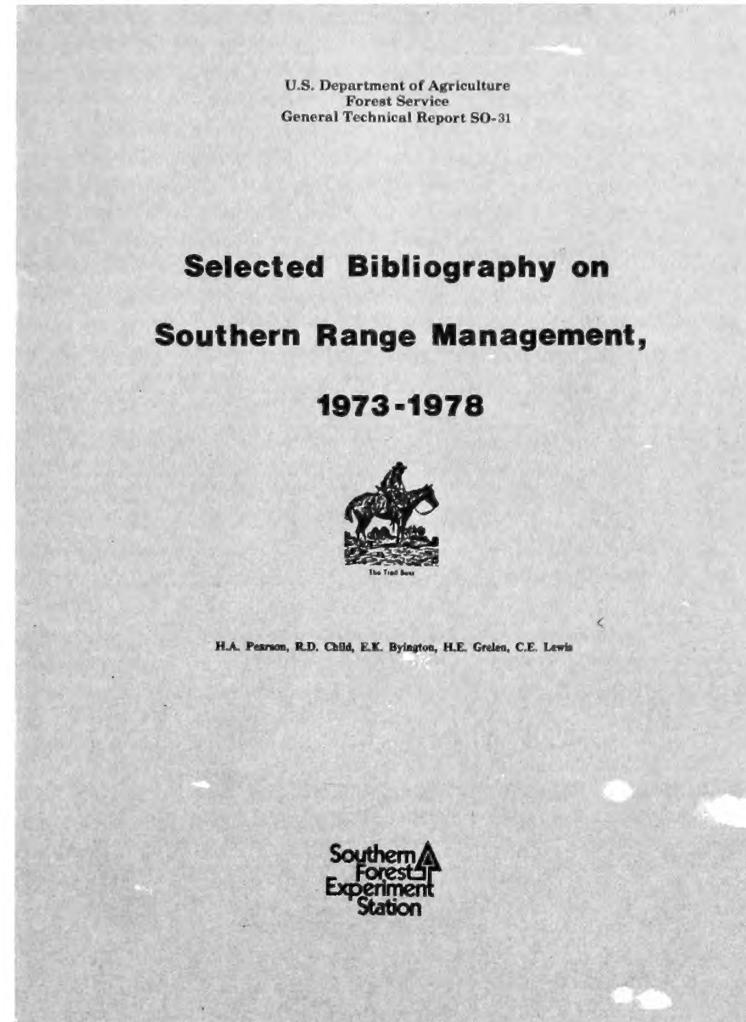
ENVIRONMENT

An innovative procedure was used to produce the 1980 *Selected Bibliography on Southern Range Management*, GTR-SO-31, fourth in a series that traces southern range management literature. A Southern Forest Experiment Station cooperator — Winrock International Livestock Research and Training Center — assembled citations into a computer-based bibliographic file. The file was then edited, updated, and indexed by a team of editors, librarians, range scientists, and technical information and computer specialists.

The 1980 publication appears similar to earlier issues in the series. Unlike manually produced versions, however, the author index, the keyword index, and the computer-produced, camera-ready copy were derived from the computer-based file. A searchable data base was also established, since the records are now part of CORR (Communications of Renewable Resources), an information resource available through Bibliographic Retrieval Services, Inc.

Now that the process is operational, it should find widespread application in other forestry and forestry-related fields.

ROUNDUP OF RANGE MANAGEMENT INFORMATION



This new publication on southern range management is the result of an innovative procedure.

PUTTING WILDLAND SHRUBS TO WORK

Many of our western rangelands have been drastically altered by human activities. Improper grazing, recreational activities, and surface mining, which can strip away vegetation or change the mixture of plants, have lowered the productivity of these lands. Erosion and flooding can follow such disturbances.

As researchers of the Intermountain Forest and Range Experiment Station develop methods to rehabilitate the western rangelands, they are seeking ways to improve the native shrubs and grasses. They are identifying natural genetic variations and selecting and developing the best varieties for specific uses.

For example, studies of sagebrush have indicated that some varieties are much better for certain uses than others. Some plants grow fast; others grow slowly. Using this information, land managers can plant one variety of sagebrush to enhance deer browse, but use another to heal highway scars.



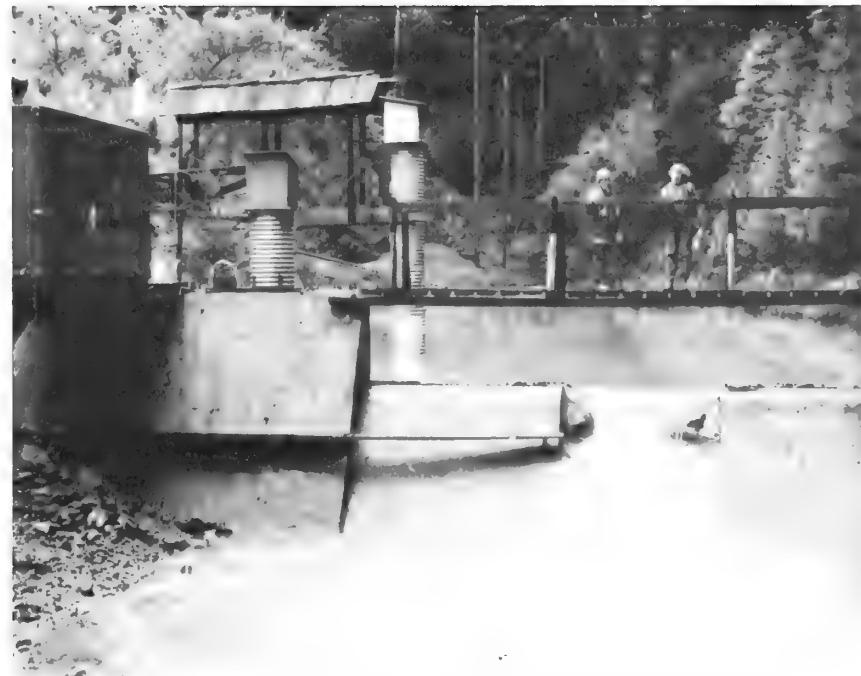
Big sagebrush (*Artemesia tridentata*) is an important native shrub of the West.

LOGGING INCREASES SEDIMENT BUT NOT FLOOD PEAKS

For years, much of the concern over possible adverse environmental effects of timber harvesting has centered on presumed increases in streamflow volumes and sedimentation in streams and rivers. The Pacific Southwest Forest and Range Experiment Station and the California Department of Forestry have recently published the results of a study giving important insights into these concerns.

The findings are based on 14 years of monitoring the Casper Creek experimental watersheds on California's north coast. Roads were built after a 5-year period of calibrating streamflow velocity and sedimentation. Four years later, about 64 percent of the 95-year-old, second-growth forest in the study area was selectively cut and removed by tractor. There was no detectable change in streamflow volume following road construction, but there was an 80-percent increase in sediment yield. After logging, only streamflow volumes less than 12 cubic feet per second increased significantly — peaks of this rate carry only 3 percent of the sediment. There was, however, a 275-percent increase in sediment yield during the 5 years after logging started.

Substantial increases in sediment discharge accompanied increases in streamflow velocity. Apparently, the principal effect of logging was the addition of eroded soil to the stream. These results strongly suggest that reducing erosion will reduce sediment from forested watersheds.



Researchers monitor streamflow following road construction and logging activities.

LARGE ORGANIC DEBRIS BENEFITS STREAMS

Large organic debris in streams is a concern of forest land managers. Researchers at the Pacific Northwest Forest and Range Experiment Station and Oregon State University have been studying its effects in streams since 1975; and results indicate that, although excessive unstable material can damage stream habitats, stable organic debris plays a beneficial role in the stream ecosystem. Large pieces of wood have always been an important component of forest streams. The biological life and topographic features in streams today have developed as a response to centuries of the movement and decay of such large organic debris.

This debris can act as an effective sediment trap, releasing material gradually as the wood decays or is worn away. The woody debris often forms a series of steps or falls in the channel, reducing the local stream's gradient and lessening the erosive power of the water.

Stable, large organic debris also provides benefits for the biological community. Fish use it for cover and protection, and some invertebrates use the wood itself for living space and for food. Needles and leaves are often trapped behind the debris and, after conditioning by micro-organisms, become palatable to stream insects.

Researchers are continuing to study the effects of large organic debris on channel stability, the movement of large pieces of wood in stream channels, and how adjacent trees add to stream debris. Forest land managers are using these findings to manage streams and nearby areas.



Large organic debris can serve a useful role in forest streams.

A NEW LOOK AT TRENDS IN THE CAMPING MARKET

The popularity of camping and recreational vehicle travel continues to grow. According to a 1979 survey, camping ranks third in popularity, after swimming and bicycling, among outdoor recreation activities. Growth of the industry slowed in the 1970's, but franchised campgrounds provided an increased share of sites. A 14-percent decline in campground occupancy in 1979 appeared to be related to gasoline shortages. The 1980 season showed a partial recovery in occupancy rates in all sections of the country except the North Central States.

Northeastern Forest Experiment Station researchers are looking beyond numbers of visitors as the only measure of how well recreation resource managers are performing. Using a simple 2-to 3-minute "report card," distributed to a randomly selected group of campers throughout the season, a composite measure of camper satisfaction is generated from 14 elements of a campground visit. Campers rank each element from "A" (excellent) to "E" (poor). A scale is used to convert letter "grades" to scores, allowing easy detection of the slightest change in the satisfaction of campers visiting a given campground or all campgrounds in a park system. Tested at public campgrounds in three States, the system is now in its 4th year of operation at all New Hampshire State Park campgrounds.



Camping activities in the United States continue to grow.

DESCRIBING THE LAND

The northern Rocky Mountains are a patchwork of forests, shrublands, and grasslands. Potential uses (e.g., wildlife habitat, livestock forage) and species composition and productivity differ greatly among and within these major vegetation types.

To achieve multiple use planning and intensive resource management on these lands, forest managers are concerned with such questions as, "What are the productive capabilities of each vegetation type?" and "How will the land respond to various management activities?"

Intermountain Forest and Range Experiment Station researchers have provided some answers to these and similar questions in a habitat-type classification system for the grasslands and shrublands of western Montana. The system is the result of an intensive reconnaissance study. More than 350 stands — 289 in grasslands, 66 in shrublands — were sampled to develop the classification.

The land manager can use the system to predict management opportunities and consequences of selected actions. For example, although the Idaho fescue/bluebunch wheatgrass type is perhaps best suited for cattle production, the abundance of forbs in this type makes it acceptable for sheep range, too. The type is also widely used by big game animals, so the manager should be alert to potential conflicts between wildlife and livestock.



Mountain rangelands on the Gallatin National Forest in western Montana provide excellent grazing for livestock.

GUIDELINES FOR REVEGETATING COAL-MINED LANDS

Many lands in the Eastern United States have been drastically disturbed by coal mining. The scars are evident on the sites of current surface and underground mining operations, as well as at unreclaimed abandoned mines and mine refuse piles.

To help reclaim these lands, scientists at the Northeastern Forest Experiment Station, in cooperation with the U.S. Environmental Protection Agency, have developed procedures for sampling, testing, and amending mine spoils. They have identified and recommended plant species and planting methods for erosion control and watershed protection, as well as for land uses such as timber harvesting and wildlife habitat. Many of the recommendations were obtained from information gathered during surveys of 30-year-old experimental tree plantings on strip-mine spoils in several Eastern States.

Their findings have been incorporated into a handbook that should be valuable to surface-mine operators, landowners, reclamation contractors, and land resource managers.



White birch grows on mine spoils in Pennsylvania.

STINGING IN THE RAIN?

No, you can't actually feel acid in the rain yet, but its effects are there. The North Central Forest Experiment Station, in conjunction with the National Atmospheric Deposition Program, has been monitoring acid rain (and snow) in lower Michigan and north central Minnesota since 1978.

Because of certain weather patterns, most of the acid rain falling in the Lake States area comes from the Eastern United States. During winter and early spring, when the soil is wet or snow-covered, weather systems from the Eastern States circulate toward the upper-Midwest and deposit acid-laden rain or snow. This is when the lowest pH values of precipitation occur in the region. Then, in late June, when the soil is drying and cultivation begins, the eastern air is met by dust-filled, more alkaline air from the Great Plains that tends to neutralize the acidity and raise the pH. Thus, the Lake States become a battleground for the two air masses. Eastern air almost always wins in lower Michigan; Great Plains air almost always wins in southwestern Minnesota.

Large fluctuations occur in the northern part of the region. Studies of lakes in northern Minnesota show that those west of Arrowhead Lake have not been adversely affected by acid rain.

Other studies are aimed at determining the effect of acid rain on forest productivity.



Researcher monitors acid rain and snow in northern Minnesota.

VOICE PRINTING BALD EAGLES

Information on survival rates, nesting territory, and possible changes in nest location in different years is vital to assessment of the stability of bald eagle populations. Traditionally, birds have been captured, marked, and released; this process risks injury to the birds.

Scientists at the Pacific Southwest Forest and Range Experiment Station are now able to identify and locate individual birds through their voice prints — sonograms that produce audio-spectrographs. The audio-spectrographs can be compared visually and measured to determine duration, frequency, and amplitude of notes for a repertoire of calls.

The scientists have been able to characterize voice patterns of bald eagle pairs at nesting sites in northern California. The studies show that these patterns provide a way to identify individual birds through several breeding seasons. Voice printing also eliminates the risks associated with capture.

Results of tests over two breeding seasons indicate that an adult eagle's voice response to human intruders near the nest site is the most suitable call for voice print comparisons. Thus, it is not necessary to record each bird's full repertoire for accurate identification.

Using the voice-printing technique, ornithologists and wildlife biologists can assess breeding population and nesting habits more rapidly, at less expense, and with minimal disturbance to bald eagles.



High-fidelity recordings of bird calls are fed into an audiospectrograph to produce a voice print or sonogram.

COMPUTERIZING THE BACKCOUNTRY

As the popularity of wildland areas grows, recreationists are encountering one another more and more. In environments where solitude is critical or where recreation facilities are inadequate for large numbers of people, use must be regulated.

Scientists at the North Central Forest Experiment Station and research cooperators at Northwestern University have developed a computerized mathematical simulation model that describes the travel behavior of campers in the backcountry. The model also shows how campsite use is affected by varying daily entry point quotas. Managers can thus experiment with different control strategies on the computer to pick the "best" one for actual use. The advantage of this approach is that congestion can be controlled, while allowing visitors free choice of travel routes and schedules once they have entered the area.

The model has been used in the Boundary Waters Canoe Area Wilderness in Minnesota and in the Quetico Provincial Park in Ontario. The method can be applied in any wildland area (such as on trails, rivers, lakes, and designated wilderness areas) to regulate campsite use without tampering with peoples' onsite activities.



Computer programs can help insure a pleasant experience in the backcountry.

A NEW WAY TO LOCATE GROUSE BROODS

In the past, grouse broods have been difficult to find. Today, however, wildlife biologists have a method to help locate ruffed grouse broods more efficiently and with less risk to the chicks. Grouse hens with broods can now be attracted to tape-recorded calls of a "lost" chick. Hens respond throughout the time they care for their broods.

Biologists must find the broods to manage populations and to assess habitat quality and devise forest management practices to improve it. The quality of grouse habitat may be the key to their production.

Scientists at the Northeastern Forest Experiment Station who developed the new method use it to determine whether grouse broods use various kinds of habitat and which kinds are best. They also use the recorded calls to capture and transplant birds. Individuals and agencies working with ruffed grouse have requested copies of the tape.



Researcher records the call of a ruffed grouse.



FIRE AND ATMOSPHERIC SCIENCES

About 9 percent of the land area in south Florida is burned each year — 95,000 acres by wildfires and 550,000 acres by prescribed fires. Are the prescribed fires achieving their objectives? What are the ecological effects of this burning? Resource managers and policymakers need answers to these questions to make decisions about fire use and control in the area.

The Southeastern Forest Experiment Station provides much of the needed information in a recent publication entitled *Fire in South Florida Ecosystems*, GTR-SE-17. This in-depth report describes the changing environment of south Florida and outlines the history of fire in the area. The report reviews the available literature and relates the responses of 10 major natural vegetation types to changes in frequency and intensity of fire. The report also discusses the relationship between burning and the spread of three introduced species — melaleuca, Brazilian pepper, and Australian pine — important trees in many locations.

FIRE IN SOUTH FLORIDA ECOSYSTEMS



Cooling down a fire set to reduce the wildfire hazard and control the encroachment of exotic vegetation.

GOATS MAINTAIN FUELBREAKS

California has a special fire management problem — 4 million hectares of chaparral that is highly flammable when mature. A system of fuelbreaks is one method used to reduce the size and number of disastrous wildfires in chaparral. Fuelbreaks are wide strips of low-growing vegetation used to break up expanses of highly flammable vegetation. They also provide an area of relative safety from which firefighters can work.

The Pacific Southwest Forest and Range Experiment Station is investigating the use of goats to control regrowth of vegetation along fuelbreaks. Goats are less expensive and more environmentally acceptable than herbicides or mechanical maintenance methods. Although goats cannot effectively reduce mature chaparral stands, they can maintain brush in an immature stage after older brush has been cleared. The degree of browsing can be controlled by varying the herd size or by confining the goats within portable fences.

When confined within a limited area, goats will browse young sprouts of all chaparral species. If given a choice, however, they prefer some species over others. The goats are especially fond of birchleaf mountain mahogany and scrub oak, but unfortunately are not attracted to chamise or manzanita.

The use of goats as a biological method of brush control is still in an experimental stage in southern California's National Forests. Managers hope, however, that as problems are solved, goat grazing along fuelbreaks will become profitable for the herders and beneficial for the forests.



The use of goats as a biological method of brush control is being tested by researchers at the Pacific Southwest Forest and Range Experiment Station.

NEW MODEL PREDICTS SPOT FIRE DISTANCE

Flying sparks or embers sometimes cause spot fires beyond the advancing front of a main fire. Fire spread by spotting is a chance event requiring the right combination of fuels, wind, and foliage moisture. When spot fires do occur, they complicate the task of wildfire control and sometimes cause prescribed fires to escape their intended boundaries. Inability to predict spotting severity increases the danger to firefighting crews and increases the chance of failure in planned fire management activities.

A new model developed by scientists at the Intermountain Forest and Range Experiment Station can help fire managers answer some of their questions about spotting. The model predicts the maximum spot fire distance that can be expected from a burning tree or small group of trees. The predicted spotting distance depends on tree species and size, windspeed, and downwind terrain. The algorithm for estimating spotting distance can be solved using a graphic procedure or a programmable handheld calculator. Although many questions remain unanswered, experience with this new model should help fire researchers and managers better understand and cope with spot fires.



Spot fires complicate the task of wildfire control.

HOW MUCH FIRE DAMAGE IS FATAL?

Lightning strikes, smoke curls upward, and fire sweeps through a stand of ponderosa pine in eastern Arizona. After the fire is out, foresters examine the scorched trees, deciding which ones are so badly damaged they should be salvaged for timber and which are most likely to survive. If too many potential survivors are cut, future timber yield may be reduced or seed trees that could regenerate the stand may be lost.

Although many factors influence the recovery potential of fire-damaged ponderosa pines, the two most important appear to be the season in which the damage occurred and the extent of damage to the tree crown. Differences in physiological condition and stage of growth make the trees more or less susceptible to fire damage during the growing season. Survival potential is further influenced by the extent of cambium damage, tree vigor, competition, insects, and moisture stress.

Rocky Mountain Forest and Range Experiment Station scientists analyzed these factors and how they interact to produce guidelines that foresters can use to improve their accuracy in marking only fatally damaged trees for salvage.



Estimating crown damage in fire-scorched ponderosa pine, Arizona.

EFFECTS OF FIRE ON WESTERN VEGETATION

Four Intermountain Forest and Range Experiment Station reports concerning the best use of fire to achieve management objectives in four major vegetation types of the West are now helping forest managers make informed decisions.

One report covers the effects of fire on vegetation in ponderosa pine communities. It includes sections on management implications and the state-of-the-art knowledge on using fire to manage these vegetation communities. The report is entitled, *The Effect of Fire on Vegetation in Ponderosa Pine Forests*, Texas Tech University Publication No. T-9-199.

Guidelines for conducting prescribed burns in sagebrush-grass and pinyon-juniper communities are presented in *The Role and Use of Fire in Sagebrush-Grass and Pinyon-Juniper Plant Communities*, GTR-INT-58. The guidelines are based on an extensive survey of literature and practical field applications.

The Role and Use of Fire in the Semidesert Grass-shrub Type, GTR-INT-85, can be used by managers to develop specific management procedures in the southern desert grasslands.

Fire Ecology and Prescribed Burning in the Great Plains, GTR-INT-77, contains vegetation descriptions and fire effects data for the shortgrass, mixed grass, and tallgrass prairies in the southern, central, and northern Great Plains. Guidelines are provided for all major vegetation types where prescribed burning data have been collected.



Balsamroot and lupine make up a large component of the herbaceous yield in this three-tip sagebrush community. Fall burning would help maintain the forb component.

HISTORICAL WEATHER DATA HELP FIRE MANAGERS PLAN FUTURE

Wildland fire management is complicated by uncertainty about weather conditions that can strongly influence fire behavior. To plan for fire operations, managers rely on historical weather records to gain insight about likely future conditions. But managers find it difficult to translate the great volume of historical weather data into an optimal management strategy.

Help has been provided by Rocky Mountain Forest and Range Experiment Station scientists who have developed two analysis aids for planning the use of prescribed fire from either natural or planned ignitions. The first synthesizes weather data into fire planning statistics that show when burning conditions are most likely to be within specified safe limits. The second provides information about the occurrence of atmospheric conditions that favor good smoke dispersion during prescribed fires. With these aids, fire managers can answer questions such as:

- “How many days can be expected to meet prescribed weather conditions?”
- “During what parts of the year are prescribed weather conditions most likely?”
- “What is the chance of several favorable burning days occurring in succession?”

These planning aids for Forest Service and other land management personnel are available as computer programs maintained at the U.S. Department of Agriculture Computer Center in Fort Collins, Colo.



Starting a prescribed fire under carefully specified fuel and weather conditions.



INSECTS AND DISEASE

Researchers at the Intermountain Forest and Range Experiment Station have developed timber harvesting prescriptions that will help save lodgepole pine stands from devastation by the mountain pine beetle.

Past studies have shown that the use of chemicals and massive timber salvage operations will not alter the course of a mountain pine beetle epidemic or reduce the loss of trees. Recent research indicates that the key to managing this destructive forest pest is preventive action *before* the outbreak of an epidemic. The mountain pine beetle prefers large trees with thick phloem. When these trees are removed from a stand, the beetle's food supply is reduced and the population cycle, which eventually leads to epidemic outbreaks, is interrupted.

The preventive prescriptions show strong promise as a method of warding off beetle infestations. Controlling these infestations will help insure future timber supplies and protect other resource values such as esthetics, forage, and wildlife habitat.

STARVE THE BEETLES — SAVE THE TREES



Researchers have developed cutting strategies to prevent kills by the mountain pine beetle.

RAPID RESPONSE TO SAWFLY DESTRUCTION

Fast work by insect control specialists and Southeastern Forest Experiment Station entomologists is minimizing damage by a new pest of white pines in the southern Appalachians. This pest, called the introduced pine sawfly, was first found in the United States early in this century. It spread through the Northeast and Lake States, but did not move into the South. In 1977, however, it was discovered in western North Carolina. The sawfly is capable of killing or severely damaging white pines, which contribute much to the esthetics of the southern Appalachians. Christmas tree plantations, representing large investments, are also threatened. Fast action was needed to determine the size of the infested area and to develop a satisfactory method of control.

Traps designed to lure and capture male sawflies were deployed in white pine stands in North Carolina, Tennessee, and Virginia. The traps contained a sex attractant or pheromone that Station entomologists extracted from virgin female sawflies. Using this procedure, the scientists determined that about 6,000 square miles are now infested — a big increase in the last year.

Examination of sawflies captured in North Carolina showed that parasitic insects that help control them in the Lake States were absent in the South. Two species that help keep introduced sawflies in check in Wisconsin were brought to a specially equipped laboratory at Linville Falls, N.C., in the spring of 1980. By August 1, approximately 100,000 of these parasites had been reared and released.

It is too early to know what the full effect of these "imported" parasites will be, but entomologists are convinced that growth of the sawfly population has been slowed. The parasites have already caused a 10-percent increase in the mortality of the sawflies. Since the parasites are effective in the North, scientists believe they will also control sawflies in the southern Appalachians.



The pine sawfly can severely damage and kill white pines.

IDENTIFYING YELLOWS TYPE DISEASES IN FOREST TREES

In 1967, Japanese scientists startled the scientific world by reporting the discovery of a link between certain yellows diseases and mycoplasmas. In some respects, mycoplasmas are micro-organisms intermediate between viruses and bacteria. Although mycoplasma-caused diseases of animals had been known since 1895, no one suspected that they could cause plant diseases. The Japanese finding spurred new research to determine the possible relationships between mycoplasmas and certain important forest tree diseases.

At the Northeastern Forest Experiment Station, Forest Service scientists conducted an extensive series of cytological investigations. Their research has produced the first scientific reports of mycoplasma-caused diseases of native forest trees. The scientists have identified the presence of mycoplasmas in the phloem of elm with phloem necrosis disease, walnut and pecan with bunch disease, and black locust with witches'-broom disease. These yellows-type diseases are characterized by an overall yellowing and dwarfing of foliage or by the development of witches'-brooms in tree crowns. Of the four diseases studied, natural transmission by an insect is known only for elm phloem necrosis; all four diseases can be experimentally transmitted by grafting.

Research is continuing to develop a better understanding of pathologic activities in diseased tissues, to discover new disease-transmitting insects, to develop selections and hybrids of elm resistant to elm phloem necrosis, and to develop methods to control these diseases.



Elm phloem necrosis has caused widespread damage in the eastern United States.

HEAT-SHOCK FUNGI MAY STABILIZE SOIL

Excessive erosion and its associated flooding are a common occurrence following fires in California's chaparral. Erosion rates up to 35 times the normal can be expected in these areas during the 1st year following a fire. Such erosion is a serious problem — over half of California's major urban areas lie in or adjacent to the chaparral zone. Federal, State, and local agencies spend millions of dollars each year on erosion control and land rehabilitation.

Within a few days after a fire, several species of microfungi have been observed growing over and through the soil — higher soil temperatures during the fire caused their spores to germinate, and competition from other organisms was removed by the fire. The mycelium (threads) of these fungi might stabilize freshly burned soil by binding together soil particles. Thus, the soil would be more resistant to erosion by raindrop impact, one of the most powerful eroding agents on burned slopes.

To test this theory, scientists at the Pacific Southwest Forest and Range Experiment Station added the fungus *Aspergillus fischeri* var. *glober* to soil exposed to rainfall. Results show distinctly lower erosion rates in soil containing the fungi than in sterile soil. Four other naturally occurring species of fungi are also promising.

This research is the first of studies designed to determine whether naturally occurring heat-shock fungi help reduce erosion caused by raindrop impact, to evaluate the significance and extent of their role, and to determine if erosion can be further reduced by adding fungus spores to erosion-susceptible areas.



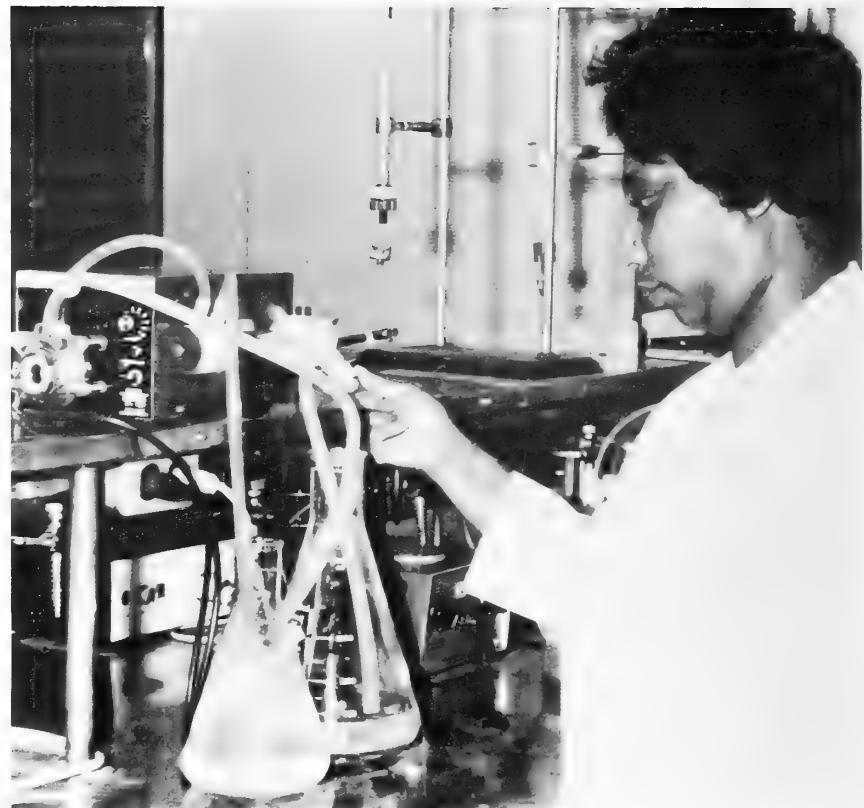
A 5-meter raindrop tower was used in trials to simulate rain impact.

SCIENTISTS DISCOVER A NEW MULTIFUNCTIONAL ENZYME SYSTEM

Researchers at the Forest Products Laboratory have isolated and identified an unusual enzyme system from a wood decay fungus. The fungus, *Poria placenta*, produces a group of enzymes capable of breaking apart complex carbohydrates as well as short-chain sugar molecules. Such a multifunctional capacity in an enzyme system has previously been unknown.

Moreover, unlike most other systems, which stop producing additional enzymes when the end product (i.e., simple sugars) is created, the production of additional enzymes by this fungus is not inhibited. Therefore, the fungus can continually synthesize the appropriate enzymes and produce large amounts of simple sugars from complex carbohydrates such as cellulose. Although additional research is needed, the ability makes possible a scheme for continuous conversion of wood to simple sugars.

Information on how fungal enzymes decay wood is critical to the development of nontoxic means of controlling such fungi by inhibiting enzymatic action. In this instance, the information might also be applied in the fungal conversion of wood waste to energy sources (alcohol) or to livestock feeds.



Ultrafiltration equipment is used to separate and identify enzymes that cause deterioration of wood.

Bt IMPROVEMENTS FOR PEST MANAGEMENT

The use of biological control measures, primarily microbial, in the management of gypsy moth and spruce budworm pest populations is a primary goal of the Northeastern Forest Experiment Station. Past research on microbial materials, particularly the bacterium *Bacillus thuringiensis* (Bt), had indicated tremendous potential, but attempts to control these pests in the forest with Bt often produced erratic results.

New research conducted at the Hamden Forest Insect and Disease Laboratory has identified several new strains of Bt (commercially unavailable) that exhibit much higher levels of activity than the commercially available bacterial strain. The new strains appear to be 2 to 20 times more potent against gypsy moth and spruce budworm larvae. Commercial interests are eager to make these new strains available for field tests.

As far as we know, the Hamden unit is the first to identify Bt strains that are more active against gypsy moth. Although field success must still be demonstrated, the discovery and use of these more potent strains may mean more effective and uniform control of gypsy moth and spruce budworm.



A fermentor is used in the production of improved Bt strains.



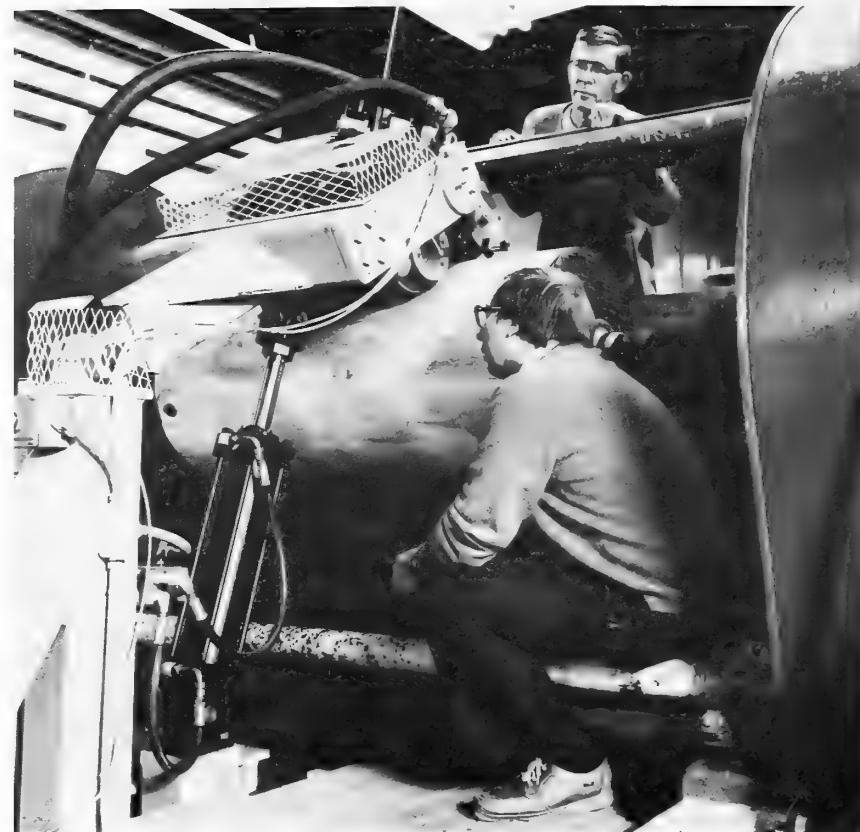
PRODUCTS AND ENGINEERING

Powered backup rollers developed at the Forest Products Laboratory are designed to eliminate spinout on veneer lathes. The powered backup device, a set of two hydraulically powered rollers, turns against the outer surface of the log as it is peeled and helps the chucks provide torque. Chucks are devices that hold and turn the log against the veneer knife. Constant pressure from a hydraulic cylinder holds the backup rollers against the log.

Spinout occurs when the amount of lathe torque created by the cutting knife exceeds the strength of the wood at the ends of the log. When that strength is exceeded, the wood fails and the lathe chucks spin free, rendering the log useless for veneer peeling. Spinout now occurs with 5 to 8 percent of the logs peeled for veneer. Since plywood, made from veneer, accounts for 80 percent of the value of all United States panel products, spinout represents a significant loss of valuable timber.

Logs with soft centers, once considered unpeelable, can now be used. The backup rollers also allow the use of smaller lathe chucks; this reduces the core diameter, thus increasing the veneer yield per log. The new process will also facilitate peeling thicker veneers, which can be used in products of the future.

POWERED BACKUP ROLLERS SAVE VENEER



Researchers check alignment of powered backup roll equipment before making a trial veneer peeling.

PREDICTING MILLWORK AND MOLDING PRODUCT YIELDS

Despite high prices for the final product, lumber grades suitable for millwork and molding products are always in short supply. About 1.3 billion board feet are needed each year for these products that include cabinets, doors, window frames, and other finish woodwork.

Researchers at the Forest Products Laboratory and the Pacific Northwest Forest and Range Experiment Station have developed and tested a computer program to predict the yield of these high-value products from mixed and lower grades of lumber. The new method shows that more lower grade, less expensive material can be used, enabling mills to alter their mix of lumber grades to suit market conditions.



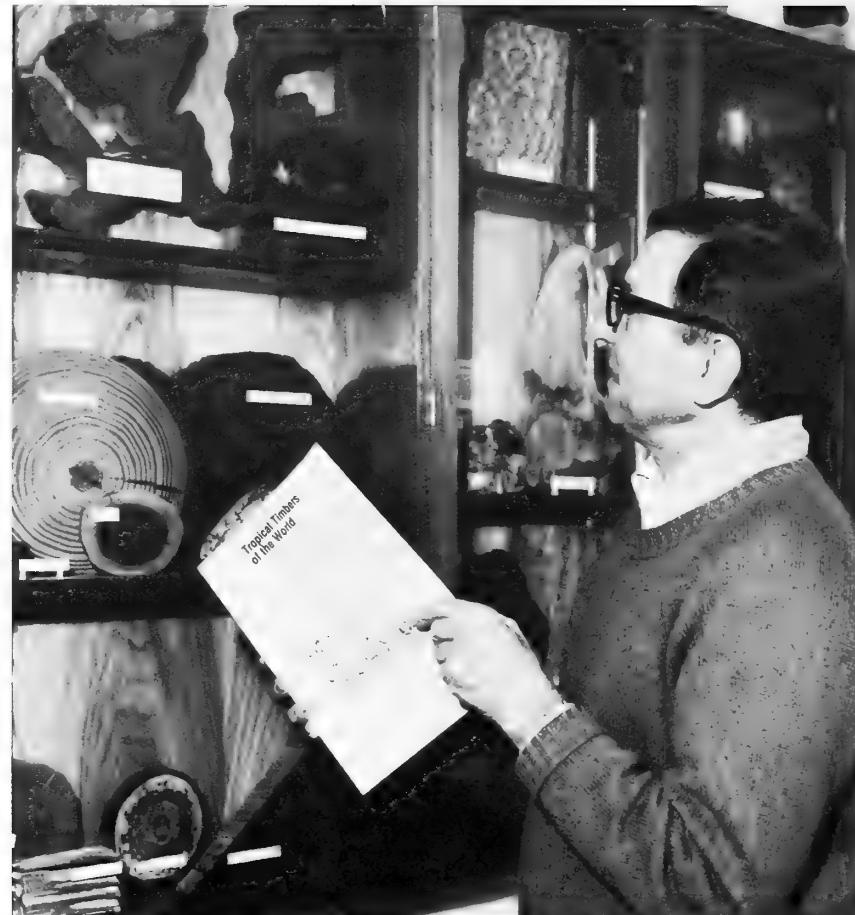
Forest Service crew measures and records board information for computer processing.

REFERENCE BOOK WILL HELP USERS OF TROPICAL TIMBER

The physical and mechanical properties of 370 tropical species from America, Africa, Southeast Asia, and Oceania are compiled, evaluated, and interpreted in an 830-page book, *Tropical Timbers of the World*.

Properties are categorized and cross-referenced to permit comparison of woods and to relate woods to specific uses. Primary users of the book will be industrial manufacturers and marketing specialists seeking sources of wood from among the hundreds of tropical species. The book will also serve as a major reference for scientists and educators who need a comparative base for specific technical analyses.

The book is available from National Technical Information Service, Springfield, Va. 22161. *Tropical Timbers of the World* ADA 086073: hard copy; microfiche.



Researcher views samples of tropical woods representative of many described in new publication.

HARVESTING PRACTICES AND THE FOREST ECOSYSTEM

Timber harvesting is the most significant management tool available to forest managers. Intermountain Forest and Range Experiment Station researchers, working with resource managers, have evaluated alternative timber harvesting practices that will help maintain productive forests.

The results of several years of research and the proceedings of a symposium are published in *Environmental Consequences of Timber Harvesting*, GTR-INT-90, a 526-page compendium. The report summarizes most of the available information on alternative timber harvesting practices in the northern Rocky Mountains. This compendium answers questions on esthetics, fire management, insect and disease control, stand regeneration and development, and other forest management concerns.



Researchers are investigating the environmental and management consequences of carrying out intensive wood fiber utilization with methods such as this skyline yarding system.

PREDICTING PRODUCT POTENTIAL OF YOUNG HARDWOOD STANDS

In order to evaluate the effects of various cutting methods, forest managers need to be able to estimate quality development, as well as growth, in potentially high-value hardwood stands. Results of a study conducted at the Northeastern Forest Experiment Station show that the individual tree characteristics important in predicting product potential and quality can be measured and combined to describe a tree or stand.

By measuring or estimating tree size, crown ratio, stem curvature, and limb-related and other defects, numerical summaries can be produced that predict the quality potential of young stands. Researchers use these summaries to identify and classify the quality of trees on research plots. They can then predict the change in quality characteristics over time and relate it to changes in product potential.



It is important to be able to estimate quality development as well as growth in hardwood stands.

NEW CHIPPING PROCESS FOR RESIDUES

Research engineers at the North Central Forest Experiment Station have developed a chipping machine that produces chips or chunks of wood 2 or 3 inches long. The material can be used for exterior grade structural flakeboard or for fuel.

Chips from conventional machines are too small to be converted to flakes for structural material. The new chipper, with a spiral cutting blade, converts small trees and residue into 2½-inch chunks that can then be ring-flaked to the required size.

Further trials have revealed another, perhaps more important, use for the larger chips or chunks. Their size gives them certain advantages over conventional pulpwood chips for fuel. For some types of industrial combustors, the chunkwood produced by the spiral-head chipper may be cheaper to produce and easier to store and handle. It may also dry better, burn better, and mix with coal better. A portable model can be mounted on a tractor, thus logging residue that otherwise might be wasted can be used. The chunkwood chipper can also serve as a compact low-cost machine for the farmer or woodlot owner in managing timber and producing fuel for home use.



Spiral-headed chipper produces chunks instead of chips, which may be better for flakeboard and fuel.

A NEW CABLE YARDER FOR STEEP TERRAIN

In the past, small tracts of timber growing on steep Appalachian slopes have remained almost totally inaccessible for harvesting. With the world's demand for forest products growing every year, such timber can be a valuable contribution to that demand.

Researchers at the Northeastern Forest Experiment Station have developed a new cable yarder, the Appalachian Thinner, that can be used efficiently to harvest trees on small woodland properties. The low-cost yarder can buck (cut trees into log lengths), yard (concentrate the logs in one location), and deck (load) as many as 40 tree-length logs in an 8-hour period. The Appalachian Thinner does not require guylines and can be transported on a 10-ton trailer, thus it can be moved easily within a timber tract.

The Appalachian Thinner is an answer to the need to remove selected timber from steep, small woodland areas at a reasonable cost.



This new cable yarder can be used efficiently and economically on small woodland properties.

PRESS DRYING ALLOWS WIDER USE OF HARDWOODS FOR PAPER

Press drying, a revolutionary concept developed at the Forest Products Laboratory, allows paper manufacturers to use, for the first time, 100-percent hardwood pulp for linerboard. The concept will also relieve the pressure on the softwood timber supply. Over one-half the timber harvested in the United States goes into paper manufacture. Of this, one-half is used to produce linerboard, the structural outer surface of corrugated boxes.

Using heat and pressure to bond pulp fibers together, press drying eliminates the need for longer, but scarcer, softwood fibers for the strength required for conventional linerboard. In addition, less refined, higher yield pulp (60 to 70 percent or higher) can be used without sacrificing product performance. Conventional processes use pulp with yields of around 53 percent.

Press drying also saves energy — the pulp needs less refining and the paper sheet requires less drying time.

The demand for softwood timber, preferred for lumber and pulp manufacture, has increased in recent years. But the demand for hardwood timber is less, thus surplus supplies of these species are available, particularly in the Eastern United States.



Researchers examine a sample corrugated fiberboard box made from 100-percent hardwood (red oak) pulp.



RESOURCE ECONOMICS

DEAD TREES IN OREGON A VALUABLE RESOURCE

There's a lot of raw material in stands of dead lodgepole pine in the Blue Mountains of eastern Oregon, and it's worth going after.

Researchers at the Pacific Northwest Forest and Range Experiment Station and the Forest Products Laboratory have evaluated this area, which contains approximately 12 million tons (dry basis) of standing lodgepole pine killed during a bark beetle epidemic in the 1970's. Although some of the dead timber is low in quality and has limited potential for conventional products, it can be used for fuel or chip products.

Results of the study show that the overall energy input to harvest, transport, and deliver the wood as fuel, within a radius of 125 miles, is less than 5 percent of the gross energy content. In terms of comparative energy value, chips from these dead trees can be delivered, within the same distance, at a cost considerably cheaper than oil. Paper mills, board plants, and producers of chip products, however, might pay higher prices for chips as raw material than those who use chips as fuel.

Experimental harvesting operations indicate that whole-tree chipping of the dead lodgepole pine would be the cheapest harvesting method.



Feller buncher harvesting beetle-infested lodgepole pine timber in eastern Oregon.

ELECTRONICS SPEED INVENTORY OF MIDSOUTH FORESTS

Researchers at the Southern Forest Experiment Station have developed a method to speed the inventory of Midsouth forests. They have integrated electronic components into a system that not only saves time, but is also more accurate and minimizes paperwork.

Continuous multiresource inventory of Midsouth forests requires the recording and processing of more than 2 million observations from field plots annually. In the past, each entry was manually recorded on a tally sheet, visually checked, and mailed to unit headquarters for keypunching, verification, and submission to a computerized edit program for error detection. This procedure usually took about 3 months, and timely advice to field crews about error sources was virtually impossible.

Field crews can now punch entries into a handheld data recorder — a device similar to that commonly used by supermarket stock clerks. Each recorder holds up to 16,000 characters of information — the equivalent of data entries from five field plots. Once recorded, the data are electronically converted to audible signals and transmitted by telephone line to headquarters where data-acquisition equipment receives and magnetically stores the information. After being edited, results can be transmitted back to the field where a portable terminal receives and prints the data for review by crew leaders who discern sources of errors and inconsistencies.

The new system will help attain the Station's goal of reducing the seven-State inventory to a 5-year cycle.



Electronic data recorders are used to collect timber stand data in Southern Forest Experiment Station surveys.

MARKET INFORMATION AIDS DECISIONMAKERS

What domestic and foreign factors affect the Nation's supply and demand for insulation board, hardboard, and pallets? Researchers of the Northeastern Forest Experiment Station have developed econometric models that answer this question. These models can be used to help provide market information on future consumption and prices of these products.

The models mathematically explain the supply-demand interrelations within each market and provide flexible techniques for annual consumption and price forecasts. They add clarity, objectivity, and flexibility to the study of wood products markets. Users of the models can measure the cause and effect of market changes.

These data are valuable to decisionmakers when formulating forest policies and programs, establishing longrun timber production and multiple-use goals, and assessing the domestic impact of export and import questions.



Better market information promotes orderly marketing and greater efficiency in product supply.

A GOOD VIEW COSTS MORE

What is an attractive forest landscape worth? While it is naturally impossible to estimate that worth, researchers at the Pacific Northwest Forest and Range Experiment Station can determine the increase in management costs for a more attractive view.

Lands on the Mt. Hood National Forest in Oregon, designated for esthetic consideration, produce the same amount of wood as standard timberlands. Additional costs are incurred, however, if managers take other measures to enhance the landscape. Such measures could include more thorough cleanup of debris and using more costly logging methods that create little adverse visual impact.

The researchers found that this increase in cost is equivalent to approximately \$2.00 per acre each year for the more attractive landscapes throughout the life of these forests. If this degree of esthetic protection is included in the cost of growing and producing timber, it represents about a 14-percent increase in direct costs.

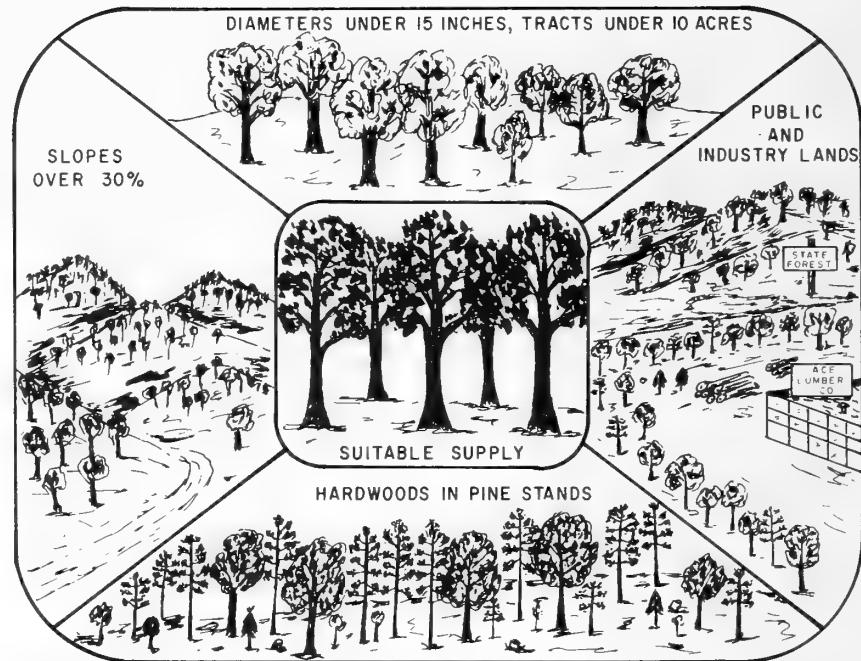


It costs more to maintain an attractive forest landscape.

CUSTOMIZED INFORMATION FOR HARDWOOD MANUFACTURERS

In recent years, forest survey reports for Southeastern States have presented an optimistic picture of hardwood timber inventories — quality and quantity appear to be increasing. Yet many hardwood manufacturers find it more and more difficult to get logs of the species, size, and quality they need. This contradiction may be caused by specialized needs of individual manufacturers and by timber stand qualities that affect availability. Resource analysts believe that the situation can best be analyzed by special computer screenings of inventory data based on tree and stand qualities described by individual manufacturers.

Consider the hypothetical example of a manufacturer of oak furniture in High Point, N.C. The Resource Bulletin for the Piedmont Plateau in North Carolina (RB-SE-32) shows 2,425 million board feet of select oak sawtimber in the region. That figure, however, reveals little about quality and nothing about availability. Furniture manufacture may require logs from trees at least 15 inches in diameter usually found in hardwood stands 60 years of age or older. Furthermore, slopes greater than 30 percent may be too fragile for logging. We might assume that timber on public lands and on lands owned by other wood-using companies is not available. Finally, we may wish to exclude private tracts smaller than 10 acres because they offer poor logging opportunities. By computer screening resource data gathered by forest inventory crews, the manufacturer learns that there are 443 million board feet of select oak sawtimber on the Piedmont Plateau that meet the specified needs.



Hardwood manufacturers can benefit from customized information about timber inventories.

CHOOSING THE BEST TECHNIQUE

A new Rocky Mountain Forest and Range Experiment Station report makes it easier for land managers and inventory planners to select the best remote sensing techniques for their particular needs. Remote sensing is the detection, recognition, or evaluation of objects by means of distant recording devices. An astronomical telescope, an aerial camera in a supersonic jet aircraft, or a sonar installation in a submarine are all forms of remote sensors.

Scientists at the Station evaluated the characteristics of most remote sensing media, including photographic and nonphotographic data such as microwave, radar, thermal infrared, ultraviolet, and multispectral scanner data. The information is included in *Remote Sensing of Wildland Resources: a State-of-the-Art Review*, GTR-RM-71. Descriptions of the information sources in the report enable users to evaluate application to wildland management.



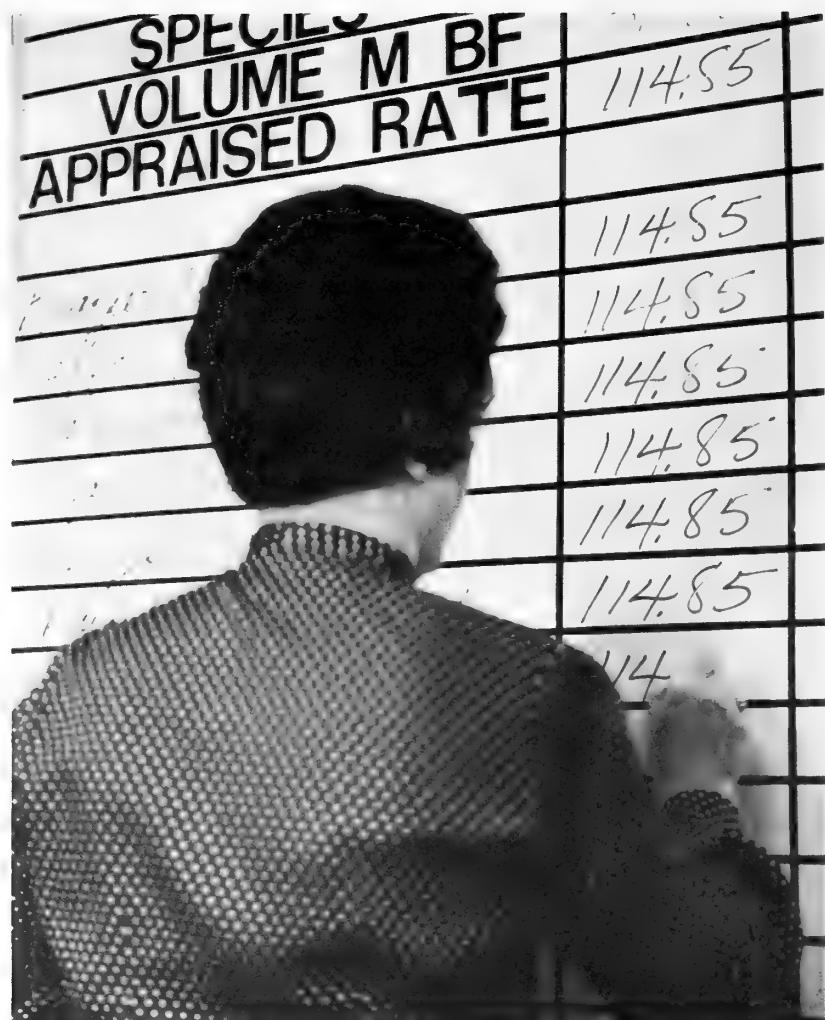
Satellite photos are one of the many remote sensing tools available to resource managers.

WHAT ABOUT NATIONAL FOREST TIMBER SALES?

The public is asking questions about National Forest timber sales procedures. Are the timber purchasers getting a fair deal? Do payments to the U.S. Treasury for timber reflect its true value? Scientists at the Pacific Northwest Forest and Range Experiment Station are trying to answer some of these questions by analyzing National Forest System timber sales data.

The Small Business Administration "set-aside" program is designed to provide special opportunities for small forest industries to compete for timber from the National Forests. An analysis of this program in the Douglas-fir region revealed that it provided a subsidy to small forest industries only in southwestern Oregon. Elsewhere in the region, both regular and set-aside timber sales had comparable prices.

The scientists also analyzed sealed versus oral bidding for timber sales in the Northern, Pacific Southwest, and Pacific Northwest Regions. For areas or types of sales characterized in the past by relatively little competition, the number of bidders and the price of timber increased when oral bidding procedures were changed to sealed bidding. Results of this research will be useful in shaping policies affecting National Forest timber sales.



Board is prepared for an oral bid timber sale, but higher prices may come from sealed bids.

FOREST LAND OWNERSHIP SHIFTS

The conversion of rural lands to other uses, particularly urban-oriented ones, is a continuing concern in the United States.

Pacific Northwest Forest and Range Experiment Station researchers analyzed private land ownership and use changes in western Oregon between 1962 and 1975. They found that approximately 210,000 of the 6.4 million acres of timberland in the area were converted — primarily for pasture and other agricultural uses. During this same period, the forest industry purchased 280,000 acres of timberland — mostly from farmers and other private owners. Although this land did not contain large volumes of timber, it had higher than average tree-growing potential (site quality). As a result of these shifts in land ownership and use, forest industry timberland area has increased 7 percent, while farm and other private timberland area has decreased 15 percent.



Small timber tracts in western Oregon are being converted to other uses.

FOREST LANDOWNERS CAN SAVE ESTATE TAXES

Death taxes, once of little concern to most nonindustrial landowners, have received increasing attention in recent years. Rising property values and inflation have made the Federal estate tax, in particular, a significant item for many people — including timberland owners. When a forest landowner dies, heirs often have to harvest timber prematurely or are forced to sell part or all of the land to pay estate taxes.

The 1979 Tax Reform Act contains features designed to lower Federal estate taxes. It provides an opportunity to reduce, in certain situations, estate taxes on real property held jointly by husband and wife. The procedure involves making lifetime gifts between spouses of the jointly owned property rights.

Using a realistic forest ownership example, researchers from Oregon State University and the Southern Forest Experiment Station analyzed the application of this legal provision to timberland owners and showed how a spouse could save over \$33,000 in estate taxes. Proper use of these techniques can reduce the need for liquid assets at death and thus lessen disturbance to the continuity of forest ownership and timber management.



Sound estate and inheritance planning is extremely important if heirs are to retain valuable forest lands.



TIMBER MANAGEMENT

Short rotation, intensive culture (SRIC) of fast-growing poplars could help the forest products industry solve the problem of a dwindling land base. Wood produced from SRIC plantations is also suitable for conversion to energy and many useful chemicals. Research at the North Central Forest Experiment Station shows that yields three to four times that of natural, unmanaged forests can be obtained from hybrid poplars planted in cultivated, fertilized, and irrigated plantations. Such a system is energy efficient, with an energy output/input ratio for the harvested and chipped poplar of 9.6.

Research on genetic improvement of poplars at the North Central and Southern Forest Experiment Stations shows that wood quality and yields can be enhanced. For example, important properties such as color, specific gravity, fiber length, and fiber-vessel ratio can be tailored for a specific mill and location by carefully selecting particular hybrids. Eight new selections for the Mississippi Delta show greatly increased growth compared with existing, improved eastern cottonwood strains. These superior strains will be produced in several State forest nurseries for public distribution.

About 13 million acres, mostly marginal farm land, are available in the northern one-third of the Lake States for short rotation, intensive culture of hybrid poplars. Additional land is suitable for planting fast-growing eastern cottonwood strains in the Mississippi Delta region.

FAST-GROWING POPLARS FOR FIBER AND ENERGY



Studies on genetic improvement of poplars show that wood quality and yields can be enhanced.

MORE FAST-GROWING TREES

In addition to studying hybrid poplars in the Lake States and the Mississippi Delta, Forest Service researchers are testing fast-growing eucalyptus species in the warm tropical environments of southern Florida and Hawaii. Eucalyptus wood can be used for paper production, but use as a substitute for fuel oil in the boilers of citrus concentrating plants or electric generating plants seems more likely.

Scientists from the Southeastern Forest Experiment Station have shown that *Eucalyptus grandis* will produce about 3 cords per acre per year on land that is currently unproductive. Over 12,000 acres of commercial plantations have already been established and as much as 3 million acres in the southern half of Florida may be suitable. Much of this land is now used as unimproved pasture, but the soil is so low in nutrients that about 30 acres are needed to support one cow.

Researchers at the Institute of Pacific Islands Forestry of the Pacific Southwest Forest and Range Experiment Station are developing guidelines for establishing, cultivating, and harvesting plantations of eucalyptus. In studies funded by the U.S. Department of Energy, scientists have shown that closely spaced, fertilized trees can grow 35 feet high in 3 years. Tests have also been conducted using a combination of eucalyptus wood chips and bagasse, a byproduct of sugarcane production, to fuel boilers. Wood chips may soon be used to supplement or replace oil and other expensive fossil fuel, which Hawaii must now import to produce electricity.



Forest Service researchers are testing fast-growing eucalyptus species in the warm tropical environments of southern Florida and Hawaii.

CLASSIFYING VEGETATION IN THE 49th STATE

Scientists at the Pacific Northwest Forest and Range Experiment Station have developed a classification system for Alaskan vegetation to assist resource managers in long range planning and development of suitable land management strategies.

The publication, *A Preliminary Classification System for Vegetation in Alaska*, GTR-PNW-106, is the result of a 4-year research effort. The classification is now used by Federal and State agencies involved in inventory and mapping of vegetation in Alaska.

The classification system has five levels of complexity. The first, or broadest, level has five categories: forest, tundra, shrubland, herbaceous vegetation, and aquatic vegetation. Each of these broad categories has four additional descriptive levels. At the most detailed level, 415 plant communities are described by the dominant species in the tree, shrub, and herb layers. The system will be revised at frequent intervals as more is learned about the vegetation in our Nation's largest State.



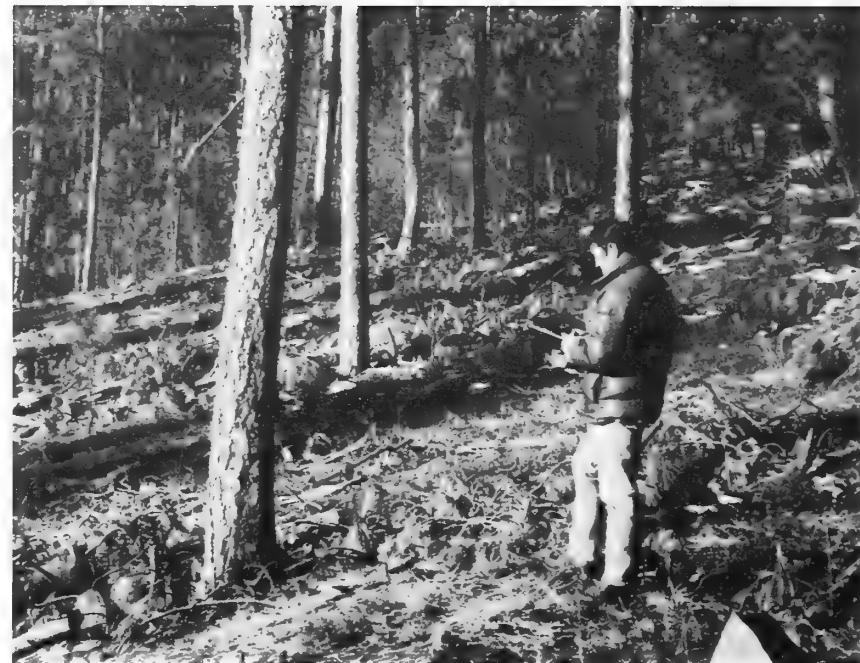
Open conifer-birch and bogs in southwestern Alaska are a major vegetation classification.

TREES AND WATER TOO

The Black Hills, heavily forested with ponderosa pine, are the source of most of the water for the surrounding Great Plains in South Dakota and Wyoming. Proposed development of coal fields in the area will cause serious conflicts, as water yields barely meet current needs.

Scientists of the Rocky Mountain Forest and Range Experiment Station believe they have found a way to reduce these conflicts. Thinning dense pine stands on the Sturgis Experimental Watershed in Wyoming increased water yields by nearly a third, while water quality remained excellent. As an added benefit, tree growth improved greatly. These increases have remained relatively constant over the 8 years since experimental thinning and show no evidence of decline.

Almost one-third of the Black Hills National Forest — some 1.2 million acres — is overstocked and could be thinned to increase water yield. This potential increase could exceed 50,000 acre feet per year, enough to meet the needs of a city of 70,000 people.



This thinned ponderosa pine stand will yield nearly one-third more water.

MANAGING AND PRESERVING TROPICAL FORESTS

Tropical forests constitute about one-half of the world's forests but they are rapidly being depleted. Because these ecosystems are critical to the existence of millions of people and perhaps to the entire world, their management and preservation is of utmost importance to scientists and resource managers.

Scientists at the Southern Forest Experiment Station, in cooperation with the University of Florida, Cornell University, and the Tropical Science Center in Costa Rica, summarized available data concerning the role of tropical forests in the world carbon cycle. This included a synthesis of available information on the production and storage of organic matter in the tropics. Data were analyzed according to life zones, thus making the synthesis useful for extrapolation to all the world's tropics. This synthesis will provide a sound basis for predicting the role of the tropics in the world's carbon cycle and will assist tropical countries in their struggle to manage their vital resources.



Tropical forests play a vital role in the world's carbon cycle.

HOW TO MANAGE THE PONDEROSA PINE

A recently published General Technical Report, PNW-97, *Silviculture of Ponderosa Pine in the Pacific Northwest: The State of Our Knowledge*, will help foresters manage 6.7 million acres of forest land in the ponderosa pine type in the Pacific Northwest.

The publication summarizes 40 years of studies — from stand regeneration to harvest. A policy of gradual removal of mature trees to maintain existing reproduction is emphasized. The report includes estimated yields of the next crop of trees and discusses pests likely to be encountered in managing the new stands. It contains over 100 references that deal with managing ponderosa pine.



There are 6.7 million acres of ponderosa pine forests in the Pacific Northwest.

MANAGERS NEED TO KNOW HOW MUCH TIMBER THEY GROW

The capacity to forecast growth and yield of a timber stand is a prerequisite of effective planning and management of the forest resource. Yield tables and models developed by Forest Service researchers are used by forest managers to formulate silvicultural prescriptions and simulate the complex process of growth over time. The managers can also analyze the financial aspects of various management alternatives.

Growth models developed by the North Central Forest Experiment Station are now available for both mature, uneven-aged and second-growth, even-aged stands of sugar maple. Using these models, based on data from long-term growth studies, forest managers in the Lake States can update inventories and compare management strategies. They can also predict yields for managed stands of this valuable hardwood species.

Using Forest Survey data, Southern Forest Experiment Station mensurationists have devised a system of equations to estimate current yield and to project basal area and volumes for merchantable natural stands of loblolly pine in the West Gulf area. Equations have also been developed to predict stand volumes for managed, natural longleaf pine for a variety of stand conditions, thinning regimes, and rotation lengths.

At the Rocky Mountain Forest and Range Experiment Station, scientists have developed a computer program RMYLD, **Rocky Mountain YieLD**, to compute yield tables for even-aged and two-storied stands of Black Hills and southwestern ponderosa pine, Engelmann spruce-subalpine fir, and even-aged stands of lodgepole pine in the Rockies. RMYLD can also compute yield tables where timber production is emphasized and where forests are managed to improve wildlife habitat, recreation, scenic, and water values. The program considers changes in stand conditions, severity of dwarf mistletoe infestation, and response to partial cuttings. The land manager can now compute yield tables for the rotation of a stand for each management alternative before financial investment.



Researchers have developed equations to predict stand volumes for managed, natural longleaf pine.

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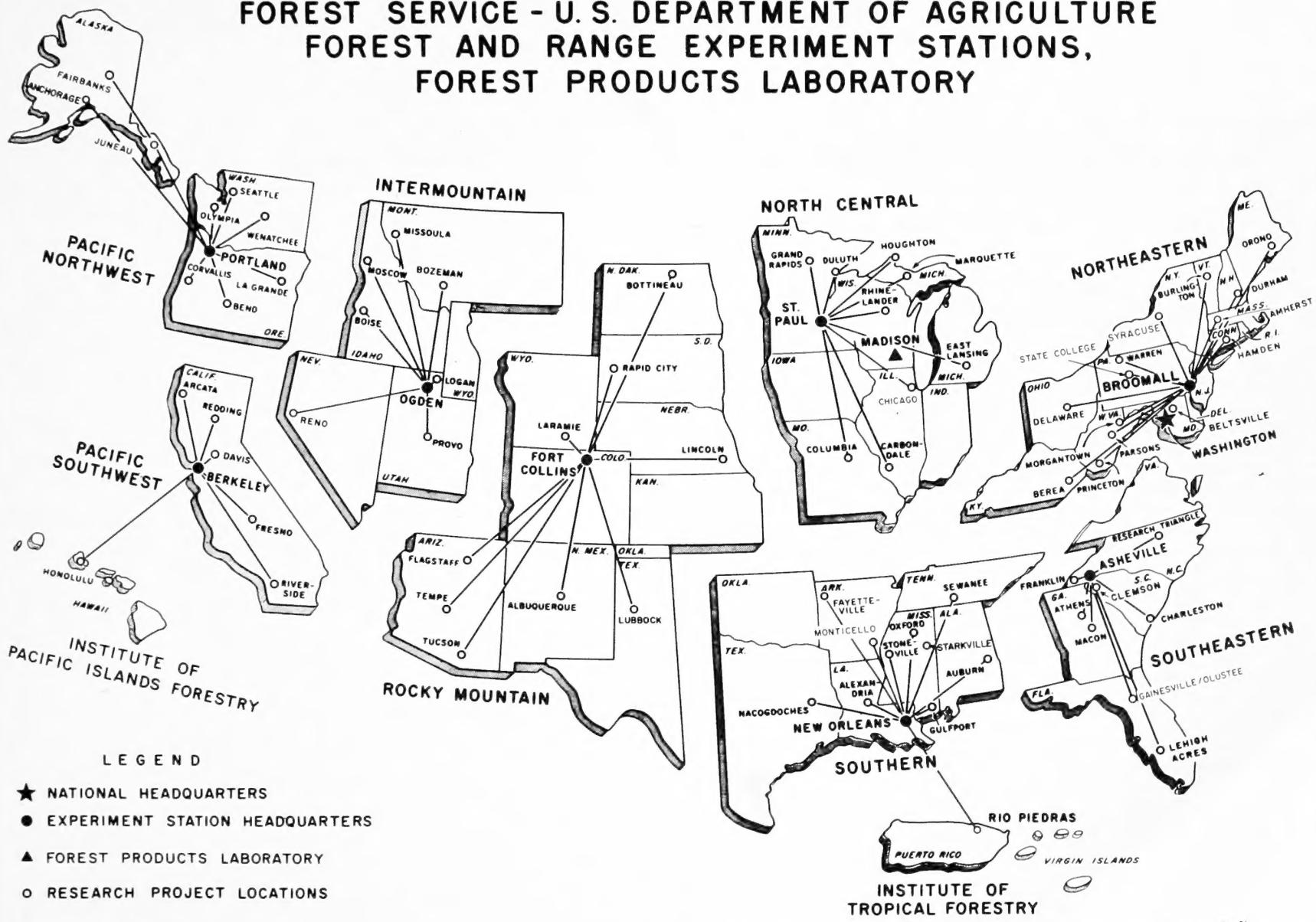
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